MINISTRY OF EDUCATION AND RESEARCH
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STUDY ON G.I.S. IMPLEMENTATION IN THE MANAGEMENT OF FLOOD EMERGENCIES. APPLICATION ON THE COMMUNES IN THE GILĂU MOUNTAINS – SOMEŞELOR PLATEAU CONTACT ZONE

SUMMARY
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INTRODUCTION

It is known that information provides the power to the beholder. The quantitative and qualitative aspects add value to information and on them can be made comparisons between organizational or decisional performances.

In order that the efforts of Government, of competent authorities and agencies, of the community, to be coordinated and to result in a community ready to face the flooding phenomenon, flood management should be carried out in an **integrated** manner.

MOTIVATION AND IMPORTANCE OF THE RESEARCH

The transition to the informational society requires the adoption of modern technological working solutions. In order to answer to the requirements of such a society, geographical information organized as Spatial Data Infrastructures (S.D.I.) is essential. The most important component of S.D.I. is the Spatial Data Center (S.D.C.), which can be defined as an electronic facility for searching, viewing, transfer, publicity, dissemination and distribution on request, of the spatial data stored in numerous sources through the Internet.

1. CONTEXT AND TERMINOLOGY

At a global level was identified the necessity to develop a spatial data infrastructures, which can ensure the foundation of policies, programs and actions, which should result in a sustainable economical and social development, and good governance. “A Data Warehouse is a database that collects and stores data from remote heterogeneous information sources” (Theodoratos D. & Timos K. Sellis T. K., 1999).

The Romanian INSPIRE Geo-portal represents the national access point through Internet to spatial information through the services enumerated above.

2. HAZARD MANAGEMENT ON INTERNATIONAL LEVEL

In these last decades, the effect of natural phenomena have emphasized the need to intensify the activities of prevention and reduction of the consequences of natural hazards, both nationally and internationally, and have highlighted the necessity for international cooperation in this field.

The necessity and opportunity of international collaboration were mentioned in a number of documents, most important of which was the United Nations Millennium Declaration, adopted at the meeting of the United Nations in September 2000, whose implementation began in 2004.

After finalization of the IDNDR (International Decade for Natural Disaster Reduction) programme, it has been replaced by the International Strategy for Disaster Reduction (ISDR). This is a partnerships system, adopted in 2000 by the member states of the United Nations, aimed to coordinate the efforts of a large number of partners to substantially reduce losses due to disasters and to build the resilience of nations and communities, as an essential condition for their sustainable development.

In January 2005 the World Conference on Disaster Reduction was held in Kobe, Japan during which was concluded that disaster risk reduction is closely related to the poverty alleviation and to the development process. The most important result of the Conference was a commitment made by 168 Governments and the international community, to strengthen the preparation and minimize vulnerability to disasters, by agreeing on an action plan for ten years. The main objective of the Hyogo Framework for Action 2005-2015 consists in integrating in a coherent manner of considerations regarding catastrophic risks in sustainable development policies, in territory management and development programmes, as well as governmental financing at all levels, and establishes the need for the existence at the level of each state of thematic platforms and of a global one, which should act as an unitary mechanism for various structures in the field of reducing the effects of disasters.

3. SHORT HISTORY OF CIVIL PROTECTION ACTIVITIES IN ROMANIA

From 2004, December 15, Civil Protection was joined with the Fire Service structure at national and local level and entered in the structure of the General Inspectorate for Emergency Situations. This was in accordance with the provisions of Law No. 481/2004, on civil protection, of Law No. 363/2002 for the approval of Government Ordinance No 88 from 2001, concerning the establishment, organization and functioning of the community public services for emergency situations, a normative act subsequently completed and amended several times, of the Government Emergency Ordinance No. 21 from 2004 concerning the National System of Management for Emergencies, and of the Emergency Ordinance No. 25/2004 approved and amended by Law 329/2004.

By decision No. 1489 of 2004, September 9 the National Committee for Emergency Situations was established within the framework of the National System of Emergency Management, as an interministerial management body, under the direction of the minister of Administration and Interior and in the coordination of the Prime Minister.

4. ROMANIAN STRATEGY OF FLOOD RISK MANAGEMENT

In accordance with Directive 2007/60/CE of the European Parliament and of the Council of the European FROM 2007, October 23, on the assessment and management of flood risks and taking full account of the specific needs, the Romanian Government drew up and approved the National strategy in flood risk management for medium and long term.

5. THE REGULATION ON THE MANAGEMENT OF EMERGENCIES CAUSED BY FLOODS

Through a joint order, 638 of 2005, May 12 of the Ministry of Administration and Interior, and 420 of 2005, may 11 of the Ministry of Environment and Forests was established The Regulation Concerning the Management of Emergency Situations Arising from Floods, Hazardous Meteorological Phenomena, Accidents in Hydro-technical Constructions and Accidental Pollution.

Under this regulation „The meteorological and hydrological information system consists in observing, measuring, recording and processing of meteorological and hydrological data, elaboration of forecasts, warnings and alerting, as well as in their transmission to the factors involved in the management of emergency situations arising from the specific risks, in accordance with the scheme of information flow set out in the defense plans, in order to take the necessary decisions and measures".

According with the Article 33 from Regulation, "The defense plans against floods, hazardous meteorological phenomena, accidents in hydrotechnical constructions and accidental pollution constitute technical documentation, prepared by the units which hold endangered objectives, by the County committees and Local committees, with technical consultation and coordination from the Water Management Systems, and from the Water Departments within the „Romanian Waters" National Administration, for the afferent hydrographic. These plans are updated every four years, in terms of technical elements and whenever necessary,

In Article 42 of the Regulation concerning management of emergency situations arising from floods are set out measures to be taken in the case of forecasting the attaining of critical thresholds or at their unattended attaining, by the County and Local committees for emergency situations.

Municipal, town, and communal committees for emergencies drown up defense plans with technical support from water management units, within the „Romanian Waters" National Administration.

The defense plan of the Cluj County (http://www.prefecturacluj.ro/index.htm) provides a summary of the plans of the local committees, and of the objectives, of the plans of hydro-technical systems, and of the warning–alert plans downstream of dams.

In the present research we present various spatial analyses whose application we can obtain the necessary information for the flood management organization and the completion of operational plans and summary reports.

6. G.I.S. IN THE EMERGENCIES MANAGEMENT IN ROMANIA

In the article „Using the digital map of Oradea in emergency situations", which appeared in the journal „Market Watch" in September 2005, Ioan Bas and Claudiu Zoicaş said that for the improvement of resource management, the Inspectorate for Emergency Situations „CRIŞANA" of the Bihor county is use G.I.S. solutions.

The article „Geospatial analysis helps firemen to fight the fire in the city of Brâncuşi" (BÂRSAN A., 2005) presents the similar action modality used presently by the Detachment of Military Firemen in the city Târgu-Jiu. For 47.5% of the city inhabitants, firemen can arrive in less than 7 minutes after the announcement of the event by telephone. In both towns "collaboration agreements" have been signed between local administrations, County Inspectorates for Emergency Situations and utility providers to create a spatial database.

The Inspectorate for Emergency Situations „Crişana" tried to extend the use of geographical information systems in risk management throughout the whole county area by the project "Floods prevention and reduction of their outcome through assistance in decision-making, based on the integrated monitoring and information system of the Bihor county" Project PHARE CBC Ro-Hu2005/017-536.01.01INTERREG IIIA (Antal E., 2008*)*.

From 2007, November 30 to 2009, August 30 the project „Reducing the risk of flooding by the development of information and communication technologies in the cross-border region", within the project PHARE CBC 2005 RO2005/017-535.01.02.04, was executed, having as partners: Constanța County Council, the Inspectorate for Emergency Situations " Dobrogea", R.A.J.D.P. Constanța, R.A.J.A. Constanța, and the Dobrich municipality in Bulgaria.

The Inspectorate for Emergency Situations „Avram Iancu" of the Cluj County has received the spatial databasis and the computer applications realized on areas of interest by the specialists of the Cluj County Council, built based on the county topographic map at the scale 1:100.000. Specialists of the two institutions, along with those of the Cluj County Prefecture, the Water Basin Administration „Someş-Tisa" and S.C. Water Someş Company S.A. collaborate and exchange data, whenever necessary, in order to realize the thematic maps necessary for the management of emergency situations at the county level, with the aid of G.I.S. systems.

7. INVESTIGATED AREA

The Law of local public administration no. 215 from 2001, April 23, regulates the general regime of local autonomy, as well as the organization and functioning of county and municipal administrations in administrative-territorial units.

The activity of emergency situations management held by public administrations is proceeds in administrative-territorial units whose boundaries are established by the Law on the administrative organization of the territory of the Socialist Republic of Romania no. 2 from 1968, February 16, with all subsequent amendments.

The proposed study area is situated in the contact zone between the Gilău Mountains, which belong to the Apuseni Mountains and the Someşelor Plateau, including the geographical area corresponding to the communes: Aghireşu, Baciu, Călăţele, Căpuşu Mare, Gârbău, Izvoru Crişului, and Mănăstireni. For each of these administrative-territorial units there are plans drawn up and approved for defense against flooding.

The contact area Gilău Mountains–Someşelor Plateau corresponds mostly to three geographical sub-units: Căpuşului Couloir, Păniceni Plateau, and Huedin Depression. The northern boundary is given by the Almaş-Agrij Depression, the western one by the Vlădeasa Massif (more precisely the Henţului Crest), the southern by the Gilău Massif and the Someşului Mic Couloir, while to the east and north-east there is a transition to the Clujului Hills (Figure 17).

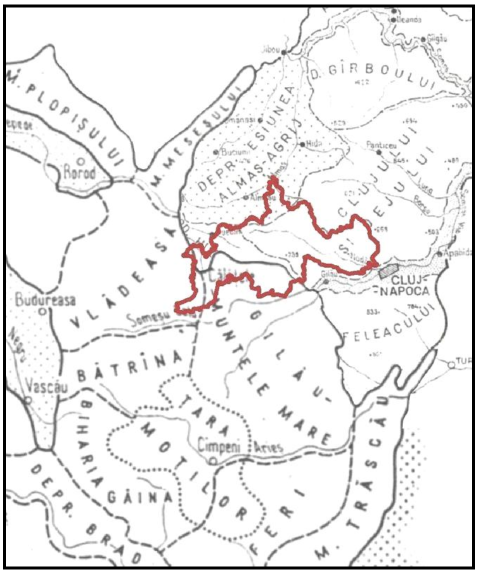


Figure 17. Elements of the study area location at the level of the main regional geographical units

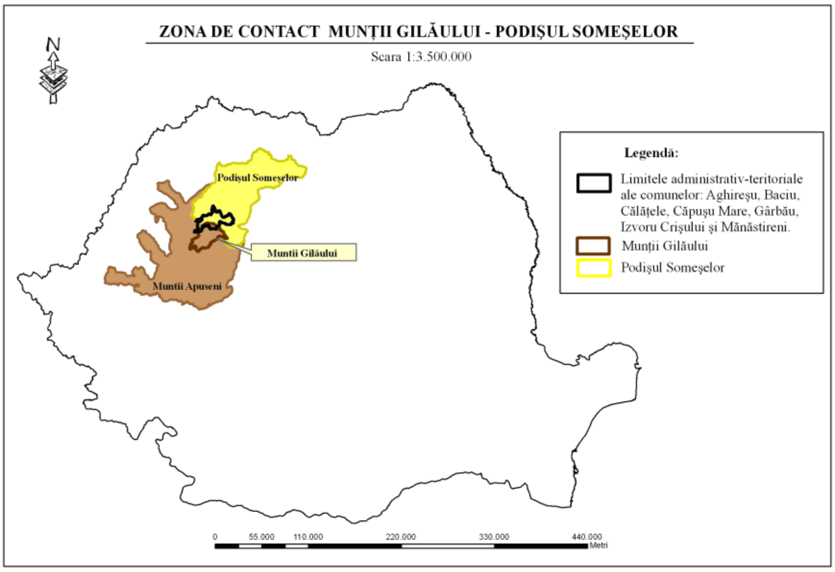


Figure 18. Placement in the territory of the communes situated in the Gilăului Mountains – Someşelor Plateau contact area.

Of course, some of the communes listed above extend their areas also to the mountainous zone (Căpuşul Mare, Călăţele), respectively to the hilly zone of the Someşan Plateau (Aghireşu, Gârbău, Baciu – Figure 18).

In terms of altitude, most of the study zone belongs to the 400 – 700 m range, with the dominance of the 500-600 m level. The relief of the contact zone of the Gilău Massif with the Someşan Plateau as a whole is given by alternate hilly units, (as structural plateaus resulted from the deepening of the rivers network in the geological formations generally from the Eocene age) with monoclinal inclination from south to north, and valleys – often asymmetric, specific to monoclinal structures.

In the study area the most important are medium-textured loamy soils with an average capacity of infiltration (belonging to hydrological group B), followed by soils with a loamy-argillaceous texture with lower infiltration potential (belonging to hydrological group C). These latter, together with the insular soils with argillaceous-loamy texture, offer at regional level the best conditions for the becoming of surface flow.

The highest degree of forestation is found in the basins of rivers descending from the mountains area (the right tributaries of Căpuş with the springs in Gilău Massif, the upper basin of Călata, etc.).

It is known that the Apuseni Mountains play the role of an orographic dam, attenuating the displacement of western air masses, and this is also felt in the spatial distribution of precipitations or humidity. The hillsides with western orientation are mostly characterized by a higher degree of moistness.

Most of the study area belongs from hydrological point of view to the hydrographic basin of Someşul Mic, through the following left side affluents: Căpuş, Nadăş, Agârbiciu, and Râşca. To a lower degree, the area is also drained by rivers belonging to the hydrographic basins Crişul Repede (Călata, Crişul Repede) or Someş (Almaş).

The shape of the hydrographic basins is an important element to be considered in the hydrological analysis of a territory, due to the influence exerted in the propagation of the surface flow. The time of concentration of the basin depends highly also on the shape of the basin, and this is later reflected in the shape of the flow hydrograph. The assessment of the shape of hydrographic basins as to circularity is based generally on information related to the perimeter and surface area of the watershed. Such a coefficient is the Gravelius compactness index. If the value of this index is close to 1, the basin shape is rounder. In Figure 27 are represented the results obtained by the application of this index in the case of the very small basins and of the areas inter-basins in the study zone.

To characterize the flow capacity from the ground surface we used two methods: the Curve Number (CN) index and the Frevert flow coefficient.

In Figure 33 the values of the CN index obtained for the study area indicate, generally, an increase of the flow capacity on the mountainous areas (preponderant afforested) to the hilly ones and to the valley couloirs.

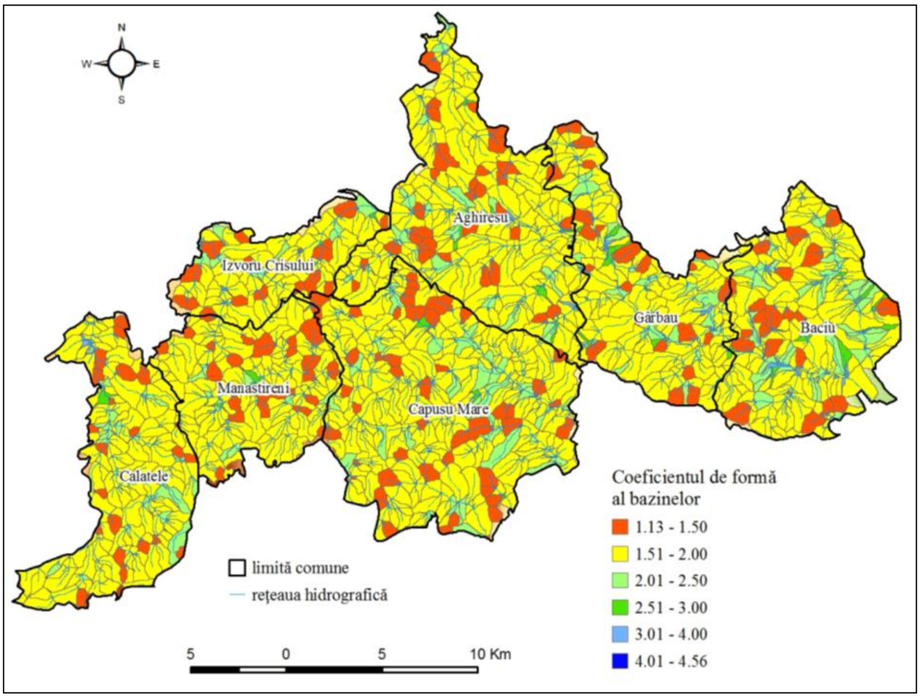


Figure 27. Shape characterization of small hydrographic basins with surface areas > 2 km^2 by means of the Gravelius index (after the topographic map 1:50.000).

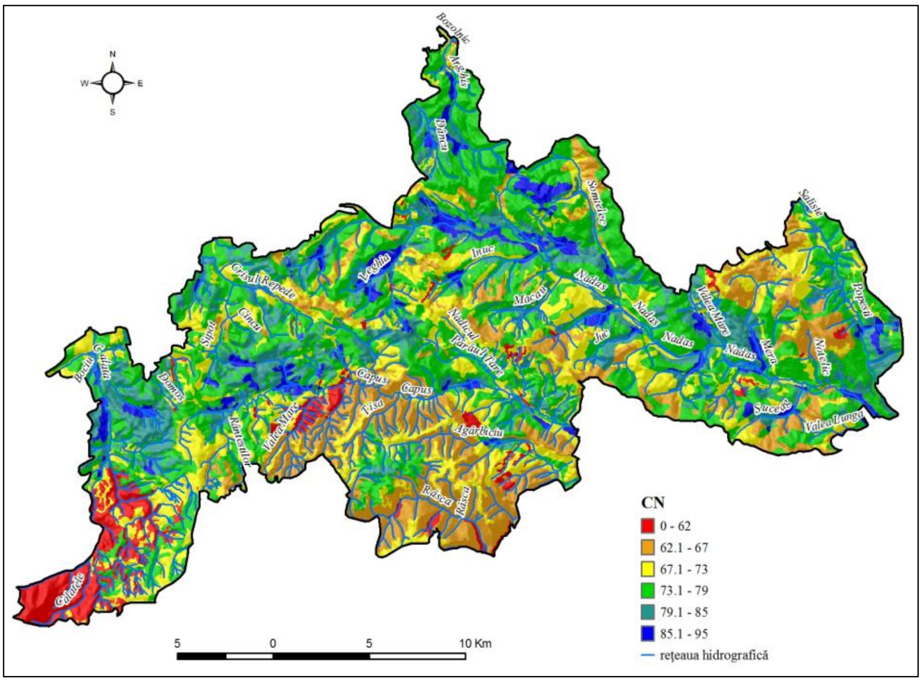


Figure 33. Spatial distribution of CN indices for the evaluation of surface flow potential for normal humidity conditions.

Overall, the areas indicated by the calculation of the Frevert flow coefficient as having a high or low flow potential (Figure 34) overlap pretty well over those highlighted by CN indices. Here also is confirmed the high vulnerability to floodwaters caused by he flow from the hillsides (in the case of torrential rains), particularly in the Nadăş and Crişul Repede drainages.

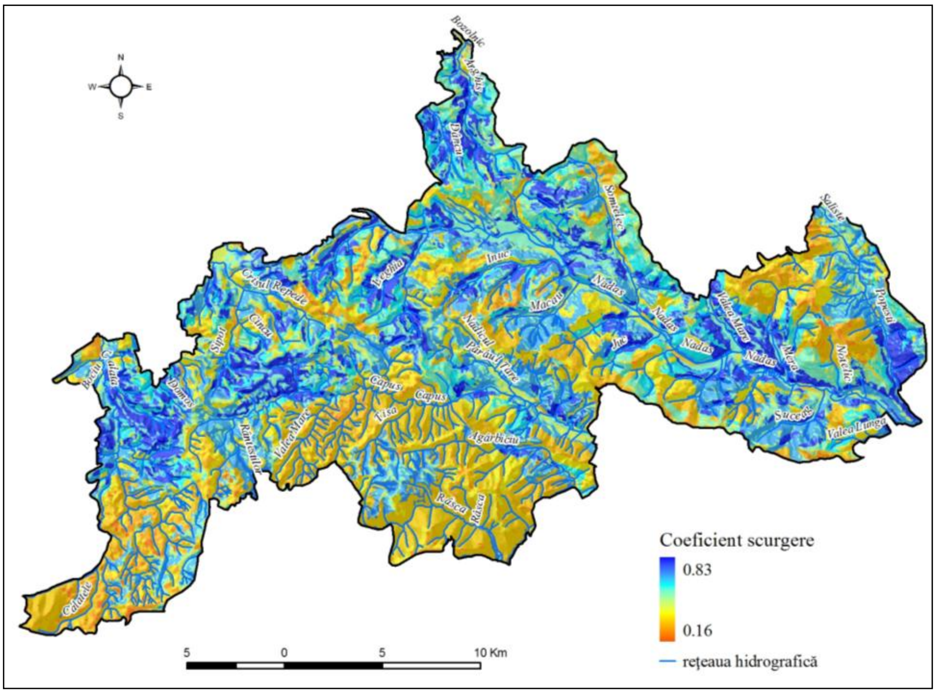


Figure 34. Spatial distribution of Frevert coefficients for the evaluation of surface flow potential.

8. AUTOMATION OF EMERGENCY SITUATIONS MANAGEMENT

The large amount of spatial information needed in the management of emergency situations referring to the territory to be analyzed must be structured in a model, in order to be able to easily manage and eliminate data redundancy. The system composed from the 8 communes can be abstracted for investigation in geographic subsystems components, administratively delimited, and interacting with each other. It is an open system, since it is in relation with its environment. Due to the large number of elements and to the links between them, it is a complex system. The model developed for the study is a deterministic system**.**

9. GEOGRAPHIC INFORMATION SYSTEMS USED IN THE MANAGEMENT OF EMERGENCY SITUATIONS

For a given territory, the spatial reference is the "key" that allows for all the documentation regarding urbanism and territory arrangement, elaborated or updated, and other specialized studies and projects, to give rise in time to a database. Gradually it will contain the history of that place and of the community living in that territory.

The realization of a digital (or virtual) geographic space requires a process of abstraction, conducted by researchers, enabling to know, understand and explain the transformations that take place on the Earth surface.

10. REALIZATION OF THE SPATIAL DATABASE

For the study, the information needed were digitizing on screen from topographical map on the scale 1:25,000, cadastral map on the scale 1: 50,000, digital orthophotos 1:5,000 and the cadastral map 1:1,000. The georeferenced data elaborated in the new Baciu G.U.P. (General Urban Plan) were uploaded into the database, updated and corroborated with each other to be consistent on the investigated territory area.

For the Baciu commune, the Defense plan has been drawn up on the basis of the tables of the commune's General Urban Plan, composed in classical format by an authorized designer in 2003.

In 2008, the G.U.P was rebuilt in georeferenced format by the firm S.C. INFORM NET S.R.L., and in present the Local council of Baciu commune is concerned in obtaining the expert's report for the documentation to come into force. The specialist designer has stored in the working folder called **Comuna Baciu** a database structured on 83 folders, with 1,791 files containing: shapes, alphanumeric information and application, etc.

Since the defense plan is made based on the information existent in G.U.P., we analyzed the data and worked on systematization and conception of a personal geodatabase structure for the new G.U.P. of the commune. The results of this activity were 214 files and 25 thematic applications corresponding to the listed plans, organized in a single folder. As a result of the data structuring, we could design a first geodatabase structure **Zona.mdb** located in a single folder, in whose classes the data were loaded/digitized and ordered.

As a result of deriving basis information and executing the spatial analysis within the present study, the initial structure of the database was modified and completed, creating a new geodatabase **Baciu.gdb,** which contains 20 de data sets.

11. SPATIAL ANALYSES APPLIEDTO THE DATABASE

The digital elevation model was executed by the digitization of the contour lines from the Cluj county topographic map at scale of 1:25,000, with the help of which was generated the terrain elevation (Figure 40). The physico-geographical characteristics with high impact on the flood and leakage from hillside are: the slope, vegetation as regards types and degree of territory extension, as well as soils. The component with the highest influence on the maximum flowing, from the viewpoint of relief, is the slope of hillsides (Figure 43). The path slope generates the floods on hillsides.

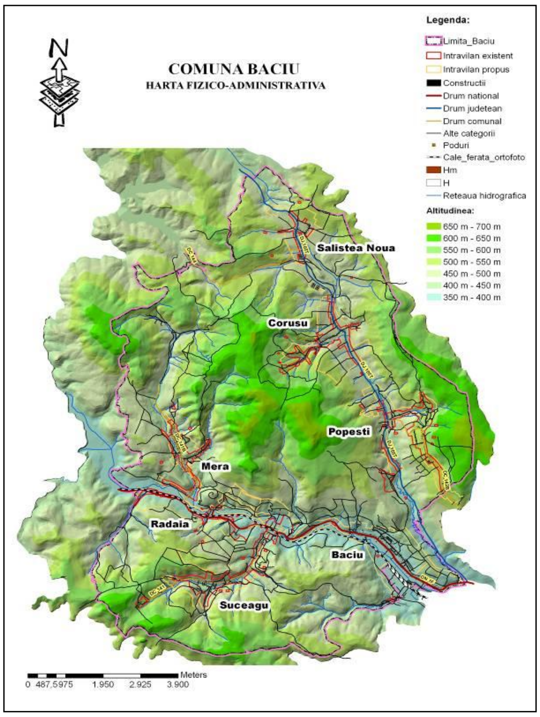


Figure 1. Physical-administrative map of Baciu commune.

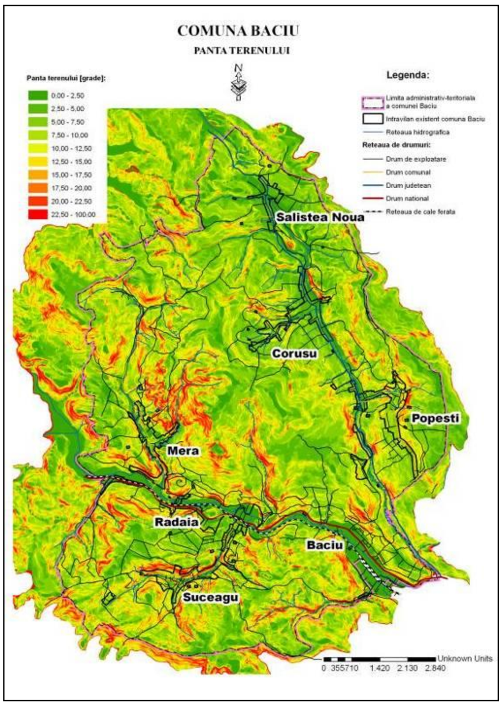


Figure 2. Land slope in Baciu commune.

Analyzing digital elevation model in the G.I.S., can be determine the area with highest sunshine exposure during a day (Figure 44)

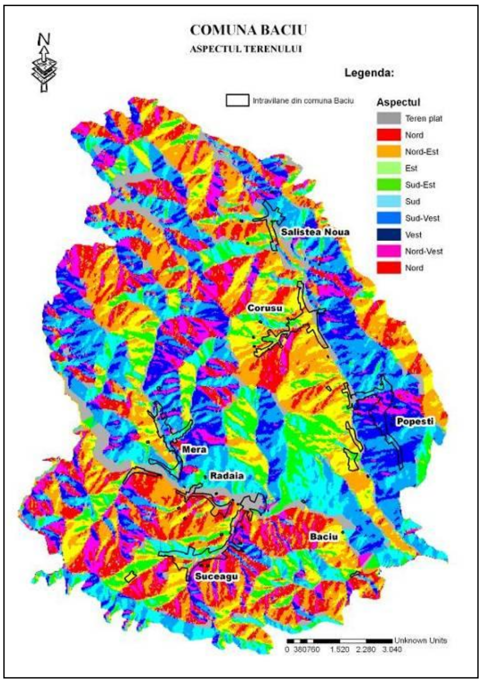


Figure 44. The aspect of the ground in Baciu commune.

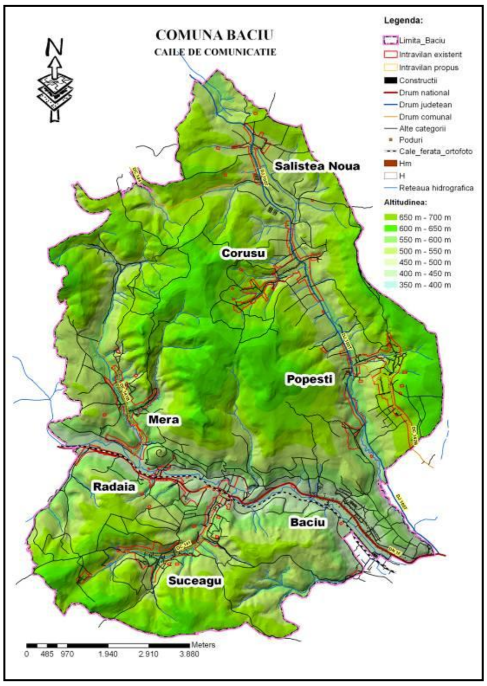


Figure 3. Communication routes overlaid on the digital elevation model.

The communication routes were vectorised after the topographic map at scale 1:25,000, checked the plans of the localities from the G.U.P. and updated in accordance with the orthophotoplans. The object classes corresponding to the networks of roads, railroads, and stations were overlaid on the digital elevation model (Figure 49).

For the whole territory of the commune we created a class with constructions, obtained by the uploading of the objects from the localities corresponding layers, identified from the plans in G.U.P. and updated in accordance with the orthophotos. The layer with constructions was converted to 3D, overlaid on the digital elevation model, and it is represented in red color for the Suceagu locality in Figure 59.

For the management of information related to the functional zones, we created in the geodatabase a set of data, in which were organized the 48 classes.

By screen digitizing were created an objects class with information about the land use, by corroborating information from the topographic map al scale 1:50,000 and orthophotoplans at scale 1:5,000, thus obtaining the sketch from Figure 61. For the Baciu commune data were downloaded from the Corine Land Cover 2000 (CLC2000) free available project (Figure 62). Information about land use is also available from 2006 year. For flood management, information from these layers can be analyzed and corroborated, in order to obtain a time evolution of the land use from studied territory. By the intersection of the land use layer with the layer containing floodable areas and built-up areas, we can get the flooded land use areas, situated in built-up area or from the outside, needed in the areas quantification process and damages evaluation.

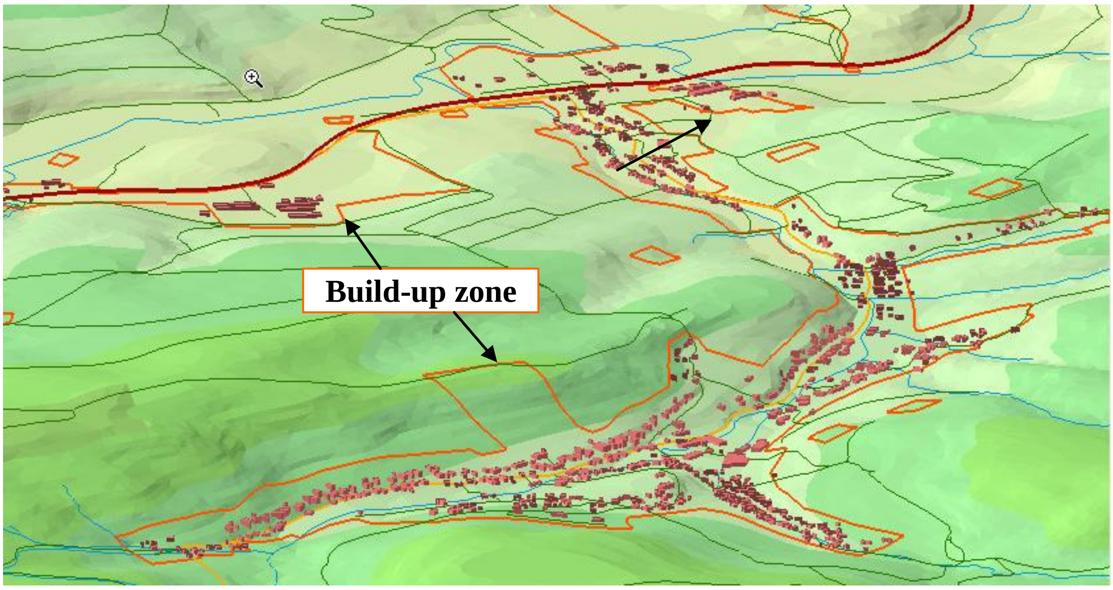
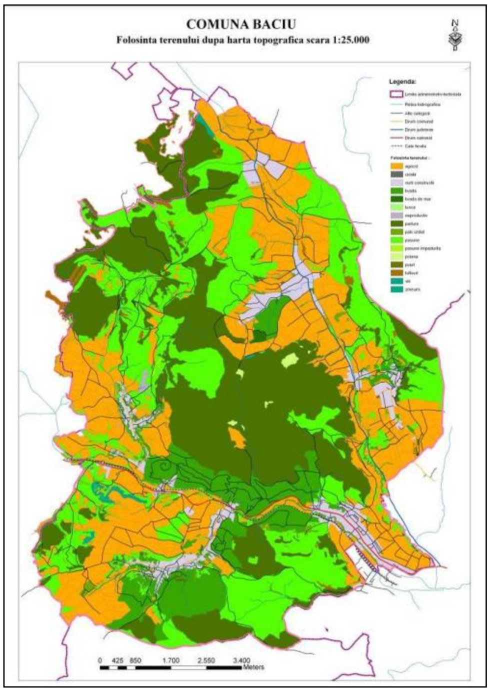


Figure 59. Modeled buildings layer from Baciu commune with the ArcScene extension.



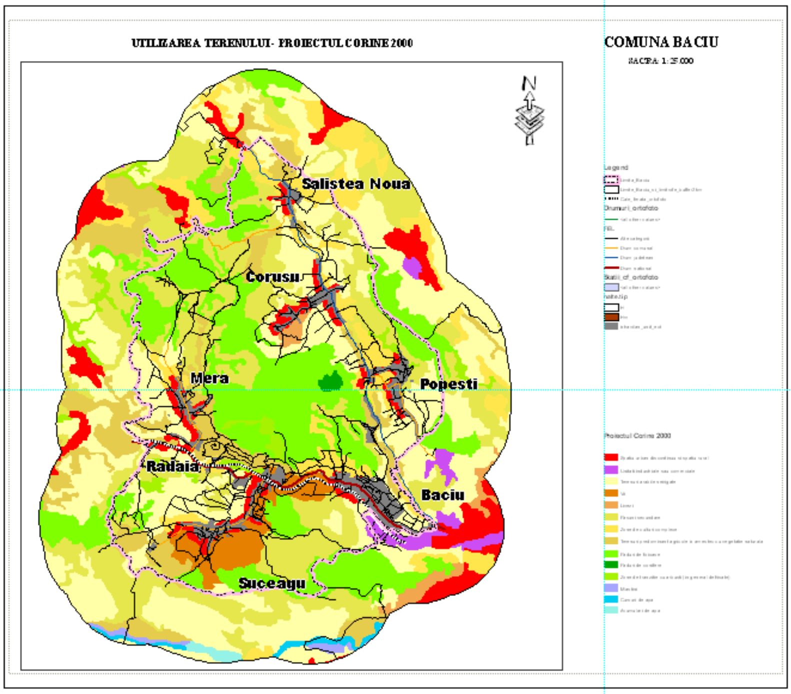


Figure 61. Land use in Baciu commune.

Figure 62. Land use from the Corine 2000 Project in Baciu commune.

In order that the area bounded as floodable to be as close as possible to the real world shape and size, information obtained and processed in G.I.S. from the G.U.P. of Baciu commune at scale 1:5,000, defense plans, topographical map at scale 1:25,000, were superposed on the orthophotoplans at scale 1:5,000, updated (from case to case), and then was drawn the contour line of the area corresponding to the altitude level 375 m (>374.596 than that provided by Mr. Câmpean Ioan) up to which reaches the water over the digital elevation model generated previously.

The shape of the continuous surface obtained for the whole commune administrative territory was then finely adjusted to take into account the configuration of land suggested by the orthophotos, the information provided by Mr. **Mihai Oancea** regarding the phenomena of growth backwater and the floods which took place, exploiting in this way some of the information collected over many years of his experience in this field, as he worked directly in the County Commission of Defense Against Disasters of Cluj.

Figure 66 presents an example of floodable area, drawn in violet, obtained by the corroboration of information, superposed over the floodable area highlighted in pink, in the new G.U.P. Within this documentation there are only 4 localities with delimitated floodable areas: Baciu, Suceagu, Rădaia and Mera. The class containing the floodable areas was converted to 3D, and superposed over the digital elevation model. Figure 67 presents the results obtained for the locality Suceagu.

In the commune defense plan against floods, there is a drawing with the whole territory of the commune, where the leakage from hillsides is highlighted, near the localities Mera and Popeşti.

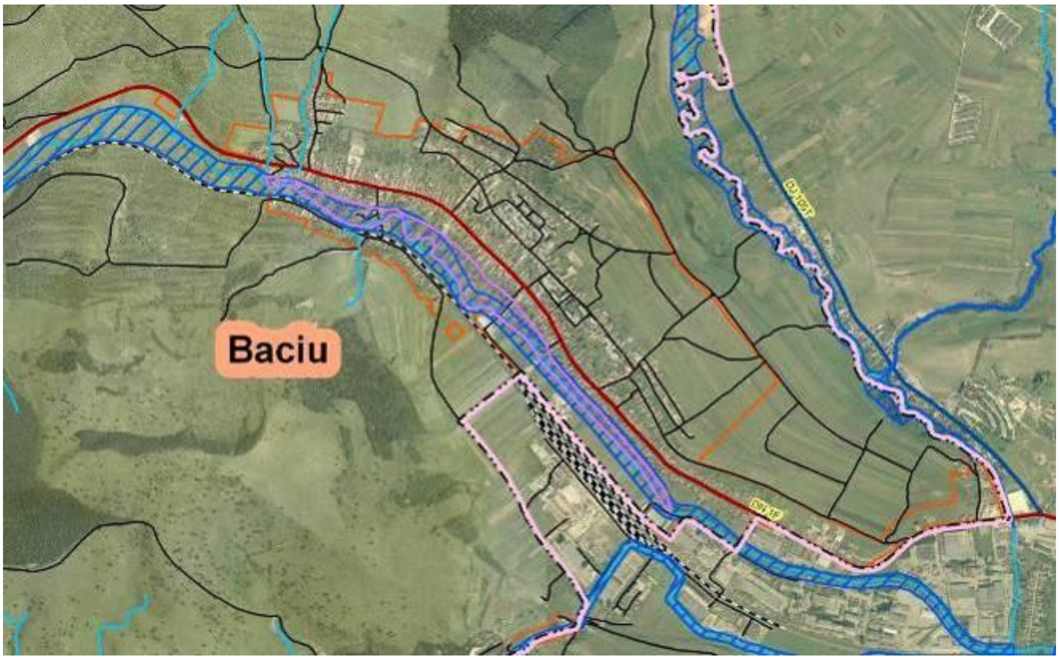


Figure 66. Floodable areas in plans of the new G.U.P. Baciu and those resulted from the present study.

The areas highlighted in the defense plan and G.U.P. were digitized on screen by identification on orthophoto saved in a separate class as polygons. We used the tool **Steepest Path** to determine the possible paths for the leakage of water from the hillsides near the urban areas. The results obtained for the locality Mera are presented in Figure 71, as oriented segments colored in strong violet.

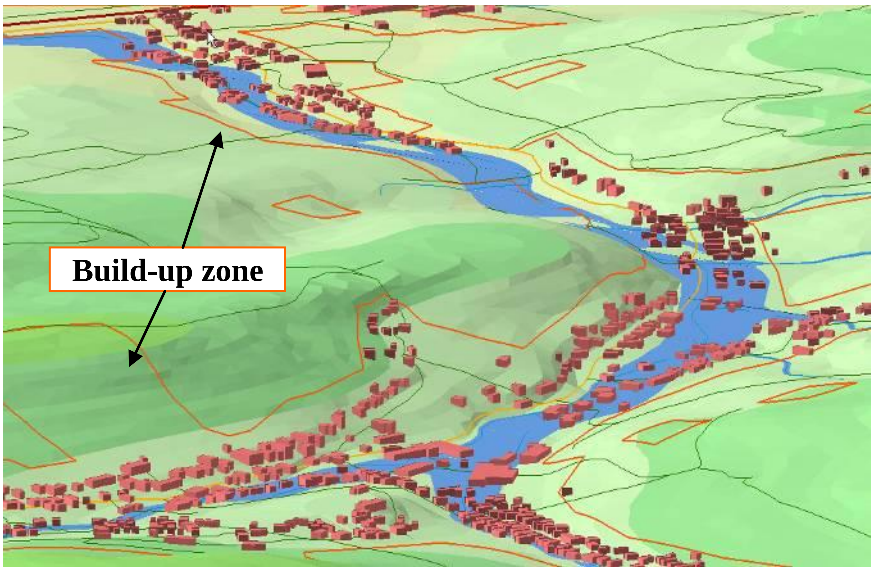


Figure 67. Modeled flood areas for Baciu commune with ArcScene.

According to our analysis on the digital elevation model, the same phenomenon can occur in the North-East of the locality Popeşti, and West of the locality Coruşu.

In order to manage information related to the public utility networks we built in the geodatabase sets of distinct datasets grouped by feature classes. For instance, for the water supply network we created a dataset **Alimentare_cu_apa**, where we grouped the layers: water supply network existing and proposed of each locality, the reservoirs, water captures and treatment plants existing and proposed. Their protection zones were demarcated in separate classes. Figure 72 exemplifies the obtained result for the locality Baciu.

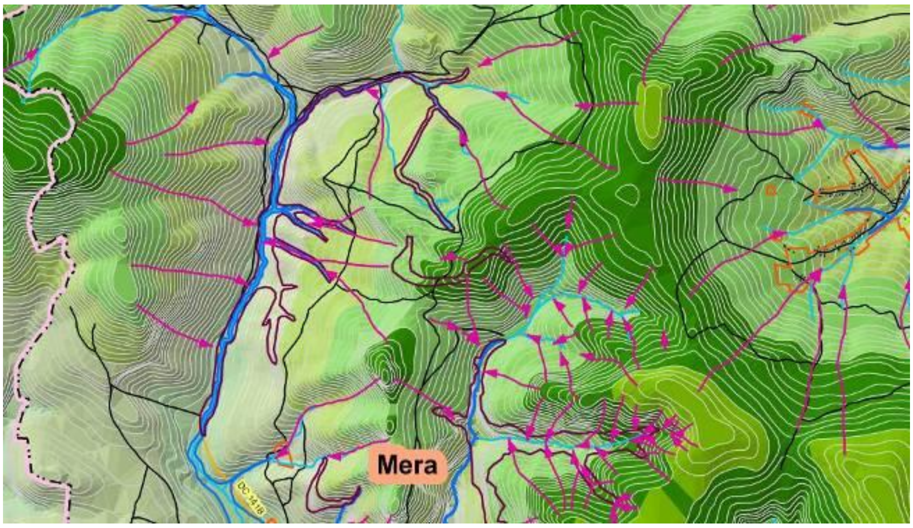


Figure 71. Leakage paths from hillsides identified for the Mera locality.

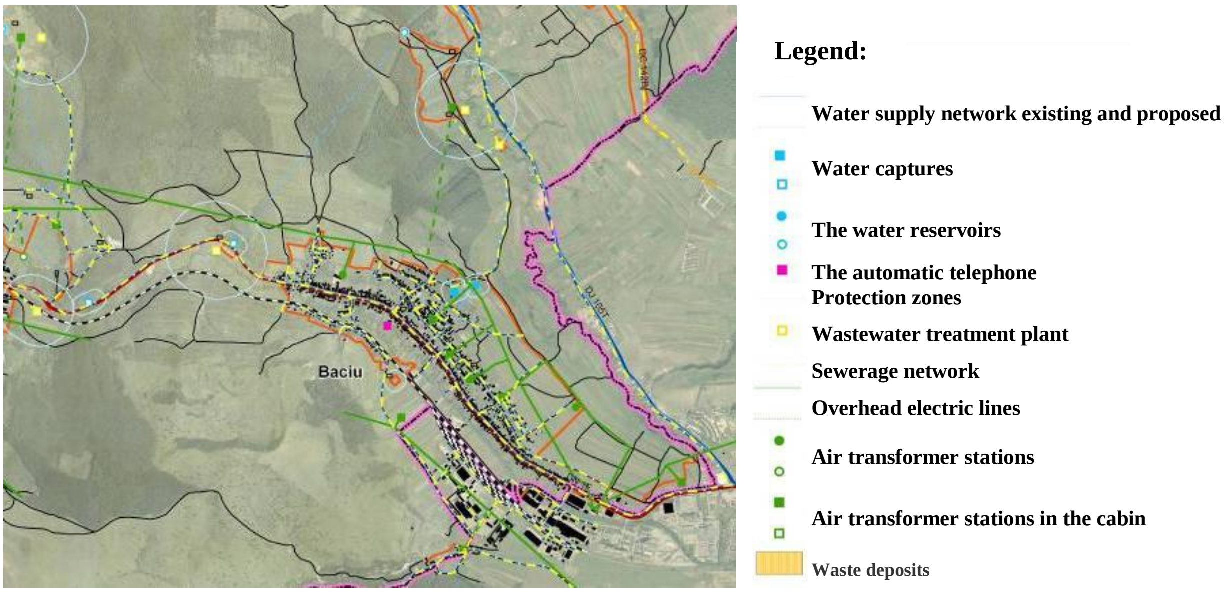


Figure 72. The public utility networks in Baciu locality.

We created a dataset **Rezervatii_naturale** where all information was organized for the natural protected areas. Two features classes were created shown in Figure 73, one containing the protected area colored in violet from the new G.U.P. (in approval procedure) and the other containing the boundary of the protected area colored yellow, downloaded free from the Ministry of Environment and Forests web site. Near the Coruşu locality is located, according to this Ministry, the Coruşu fossil zone presented in Figure 74 as the yellow hatched area while according to the new documentation of the G.U.P., there are two fossil areas, highlighted in the figure by violet color. The situation is quite delicate, since some of the existing buildings are located in the protected area, according to the Ministry's data.

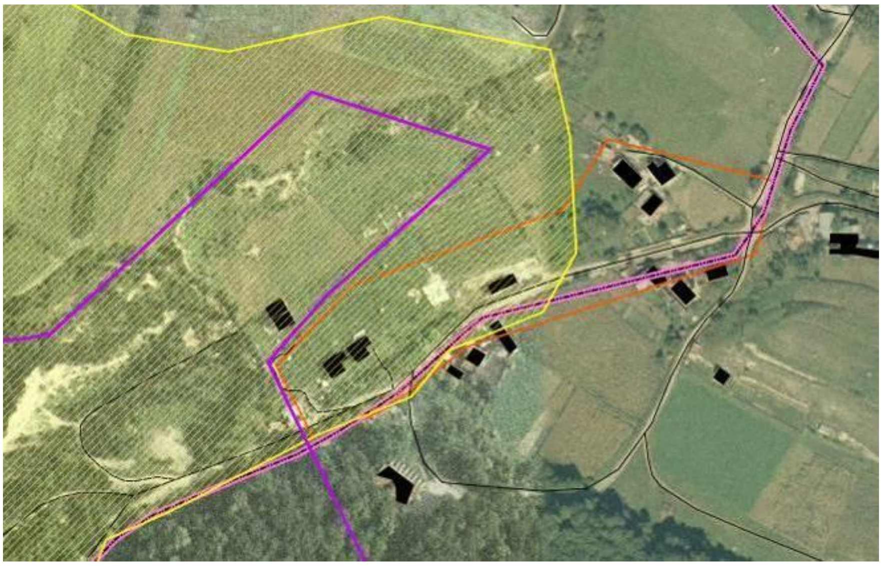


Figure 73. „Cheile Baciului" protected zone.

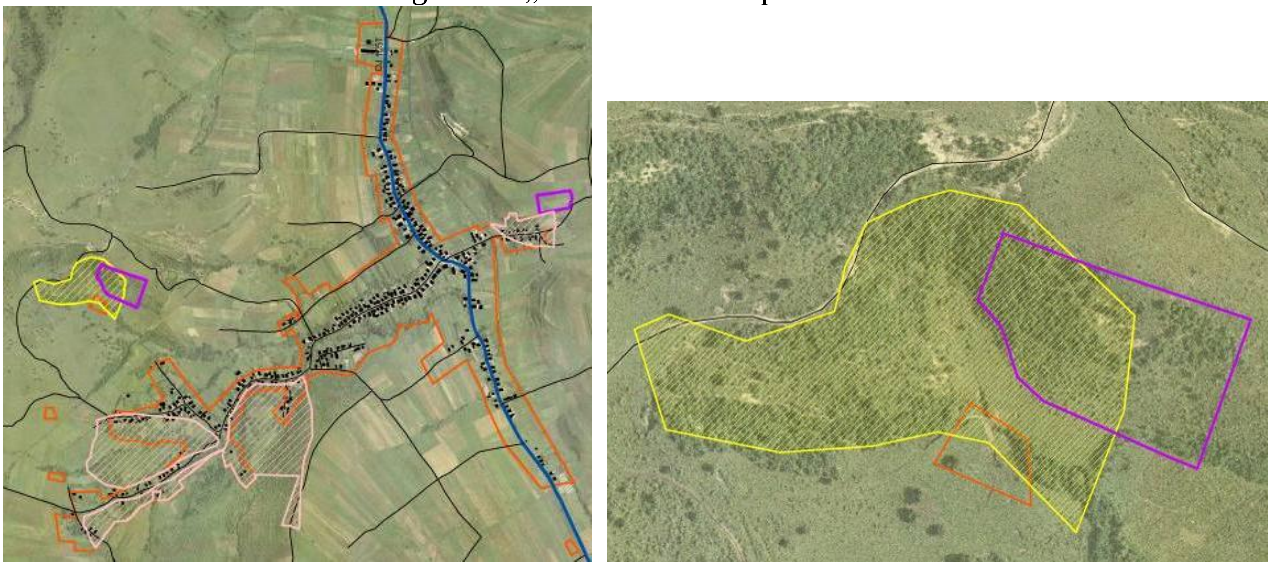


Figure 74. The fossil areas near the Coruşu locality.

In the picture it is observed that part of the built-up area proposed by the new G.U.P. highlighted in orange overlaps the only existing fossil area in the evidence of the Ministry, a situation which should be considered in the stage of approving the G.U.P. Both protected natural areas are positioned in outside the floodable areas.

„At the level of the commune administrative territory, several evacuation areas should be established, which could be used depending on the number of people, animals and fowl to be evacuated and on the living conditions which can be provided. ... As a matter of principle, these areas should present a slope as small as possible, a sunshine exposure during the day as large as possible, they should be as close as possible to the built-up area of the locality from where the flood victims are evacuated and should be located on agricultural land” (Nicoară M., Haidu I. & Imbroane AL., 2010).

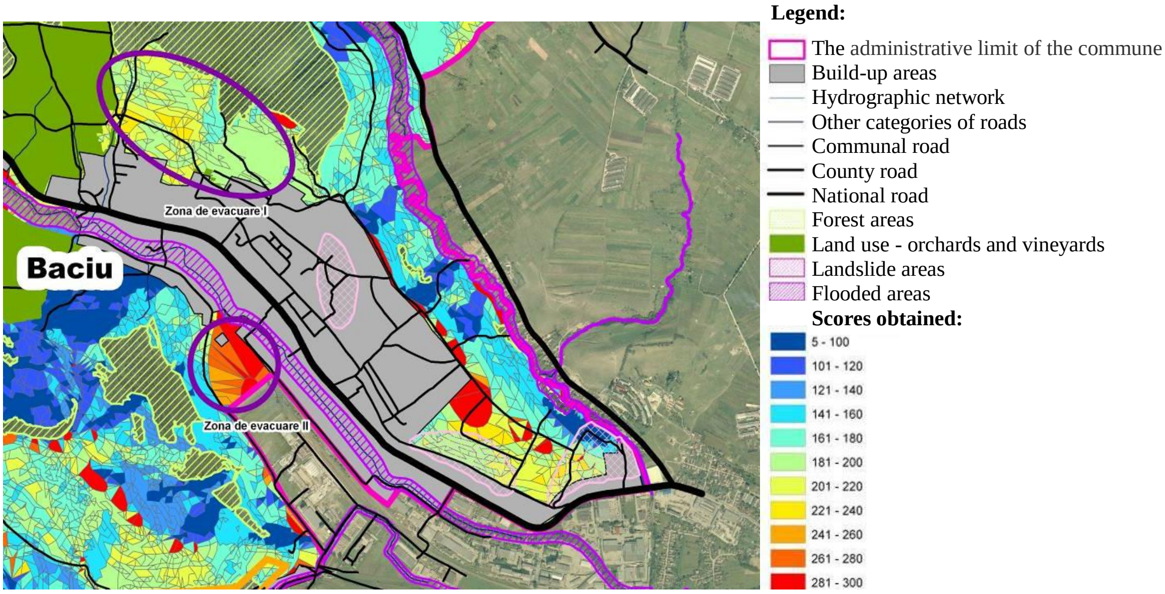


Figure 84. The evacuation areas resulted for the Baciu locality.

As a result of spatial analyses, for each area of land a partial score was assessed based on the rule of three. Finally, each area obtained a total score resulted by the addition of the partial score awarded. Based on the resulting scores were found for instance that for the locality Baciu, the people, animals and fowl accommodation might be carried out in two zones, according to Figure 84.

To identify constructions located in floodable areas, the command Intersect was applied. In this way a layer was obtained, containing the constructions situated in floodable zones. In Figure 96 are presented in yellow some of those, situated in the locality Baciu. The total number of constructions possibly affected in the commune is 514.

Figure 96. Constructions in the locality Baciu, located in floodable zones.

Intersecting the class containing the roads network with that storing the floodable areas, we obtained the roads sectors affected by floods. In Figure 97 is presented an example with affected roads sectors. County and local roads affected are colored in turquoise and the others in yellowish-green color.

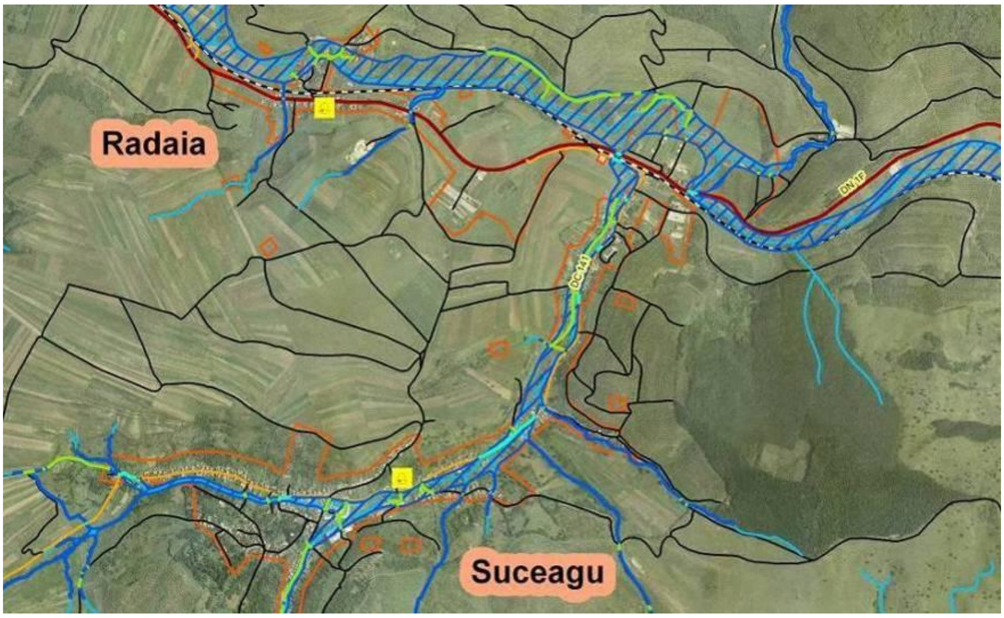


Figure 97. The roads affected in Baciu commune.

The total length of the affected roads sectors is 15.362 km, from which national, county and commune roads represent 3.273 km.

11. CREATION OF THE MODEL OF SPATIAL DATA TYPE NETWORK

In the present work, 6 scenarios were modeled to analyze how evacuation process of the households located in floodable areas can be done, using the Network Dataset model for the roads network. In scenarios the evacuation time was considered the most important. For the displacement, were taken into account two modes of transport: with individual's own vehicles and special vehicles provided by the municipality. The scenarios have been approached simply and logically.

12. EVACUATION SCENARIOS

In the first scenario we proposed to determine the distance to be traveled by a family residing in a locality by its own vehicle in order to get to an evacuation zone, in a certain time period (Figure 115).

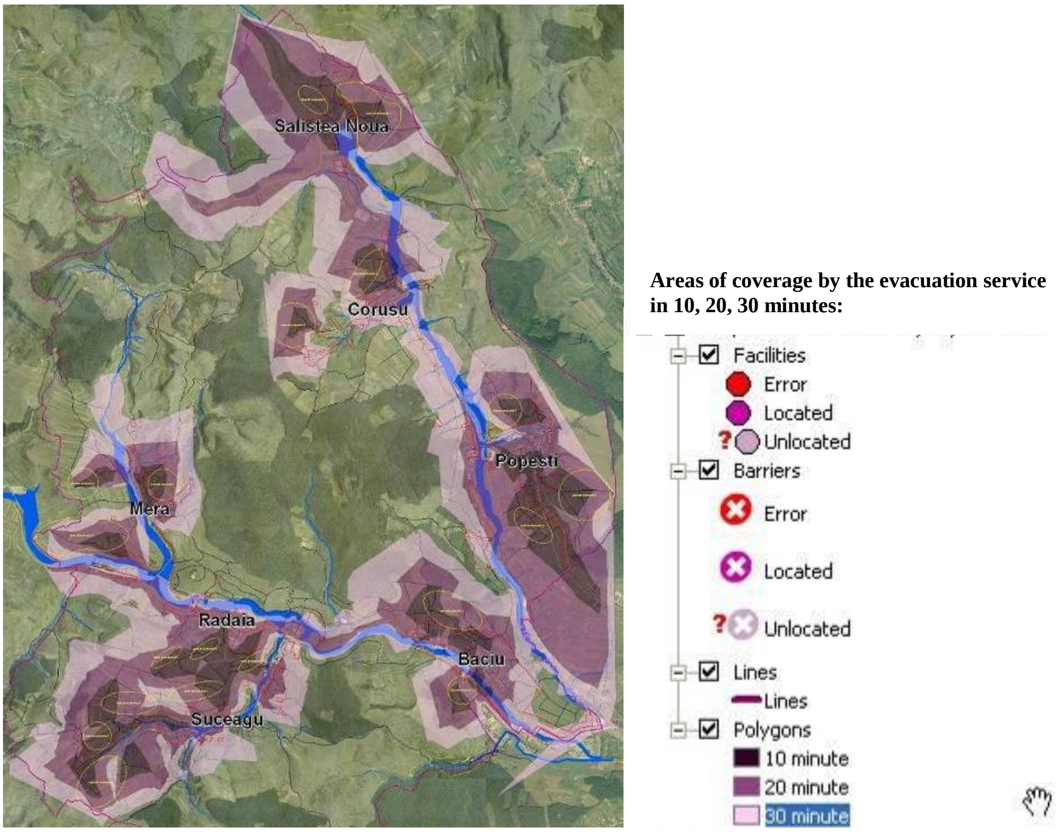


Figure 115. Areas of coverage by the evacuation service in 30 minutes

By the overlay technique we identified on screen the households from which people, animals and fowl cannot be transported within 30 minutes to the nearest evacuation zone (Figure 116). In order to identify constructions which can be evacuated we applied the analysis type **New Service Area.** In Baciu commune there are 3,860 constructions. Among them, 546 are located in the floodable area.

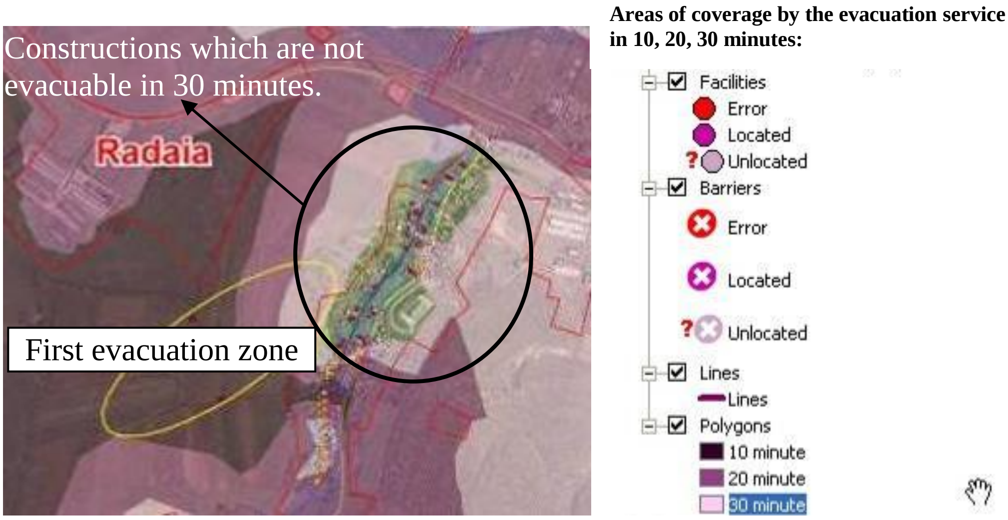


Figure 116. Constructions not covered by the evacuation service for the locality Suceagu.

In the second scenario, we proposed to extend the evacuation time to one hour, to see if the evacuation process can be fully completed. The same type of analysis, **New Service Area** was applied and the results obtained for the whole commune are presented in Figure 122.

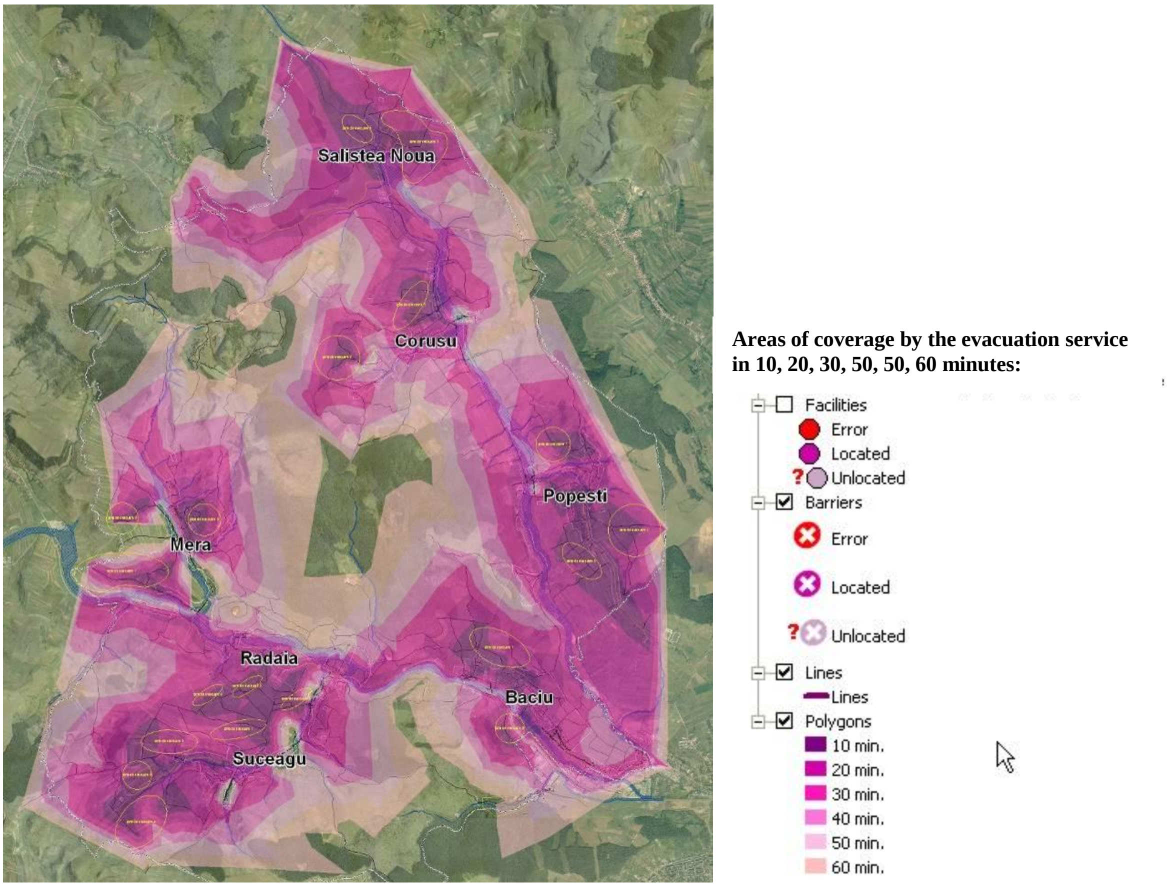


Figure 122. The covering polygons with the evacuation service in one hour.

In the detail from Figure 124 are highlighted in green color the constructions not covered by the evacuation service within 60 minutes.

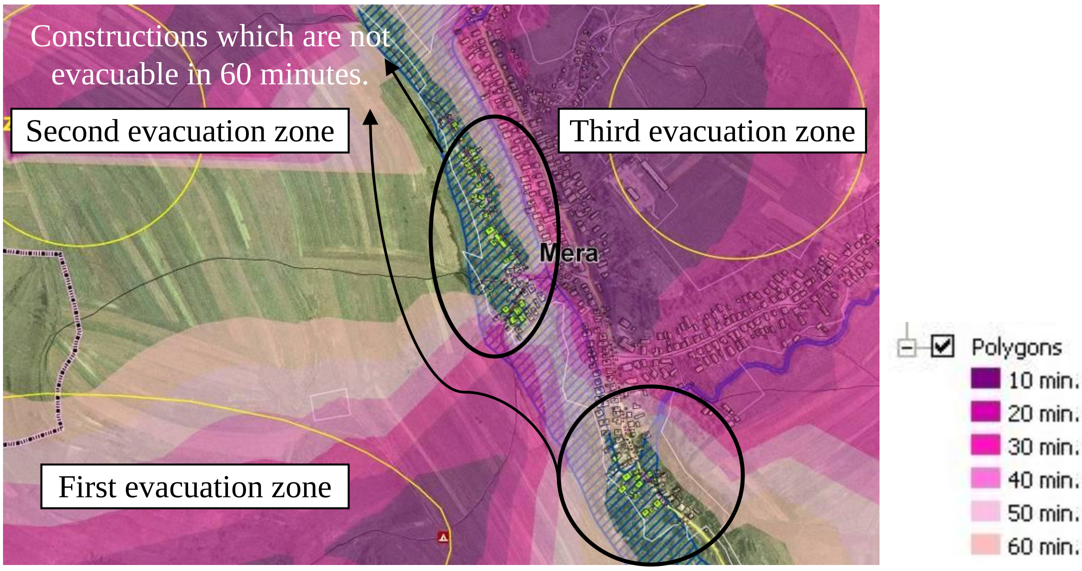


Figura124. Constructions not covered by the evacuation service within 60 minutes.

From our analysis resulted that 40 % respectively 153 constructions are not covered by the evacuation service within 60 minutes, among them: 88 are homes and 65, household annexes. The localities: Baciu, Popeşti and Săliştea Nouă can be completely evacuated.

The third scenario was modeled to identify the access routes to the nearest evacuation zone, using for travel any car of each household of people and eventually pets, during an hour. The **New Closet Facility** spatial analysis type was applied**.** In the Baciu locality 82 people evacuation routes were identified and for each one, length and time travel were specified. In Figure 129 are presented in violet, some examples of evacuation routes for households of the Baciu locality. The constructions are represented with red in the floodable zone, which are highlighted by a blue hatch.

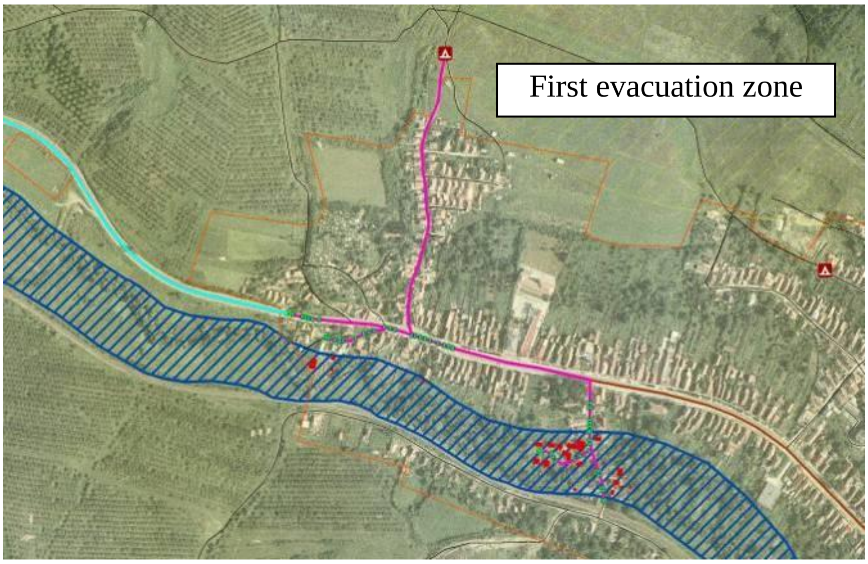


Figure 129. Evacuation routes for households in the locality Baciu.

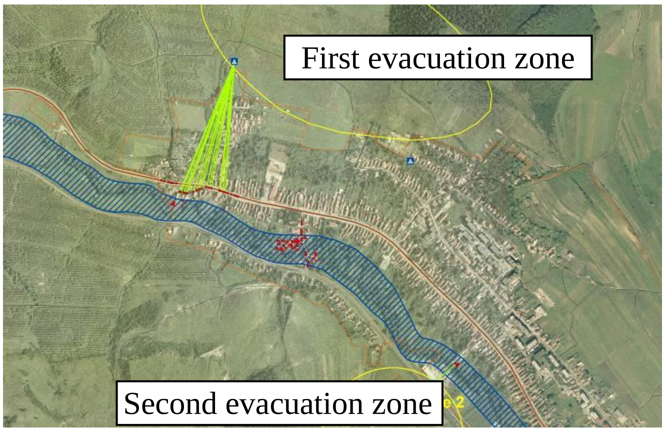
Within an hour all constructions from the Baciu locality can be evacuated. For the Rădaia locality, 26 evacuation routes resulted. In the Popeşti locality there is a single household, which cannot be evacuated within the imposed time limit, since it needs 62.58 minutes for evacuation. All constructions in the Săliştea Nouă locality can be evacuated. For the Mera locality, we identified 189 evacuation routes and 125 constructions which cannot be evacuated within 60 minutes. By applying the analysis for the Coruşu locality, we identified 16 constructions which cannot be evacuated within 60 minutes, and 76 evacuation routes. In the Suceagu locality, we obtained 226 evacuation routes and 76 constructions which cannot be evacuated. This scenario results reveal that people from 212 homes cannot access within an hour, the nearest evacuation zone.

Before the manifestation of the dangerous phenomenon, the manager of the evacuation process should know in which evacuation area are transported people, animals and fowl which live in a specific location, identified by a house number. Important for this type of analysis is the time, since depending on the time allowed evacuation process, people can move to certain access points using their own means of travel.

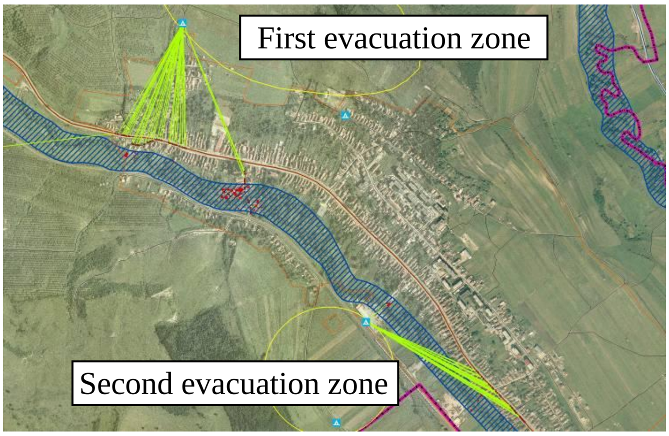
To meet the requirement formulated in the fourth scenario, on the Network Dataset was applied the **Creating an OD Cost Matrix** (cost matrix Origin-Destination) analysis type. The analysis result is a table which contains the total impedance from each origin to each destination. The found path is shown graphically as a straight line and represents the route to the nearest evacuation point to which people can move during: 10, 20, 30, 40, 50 and 60 minutes.

Among the 684 households of the Baciu commune, represented in the roads network by their house numbers, for 86 only were found direct routes for evacuation during 10 minutes. The results obtained for the locality Baciu are presented in Figure 139 with light green lines.

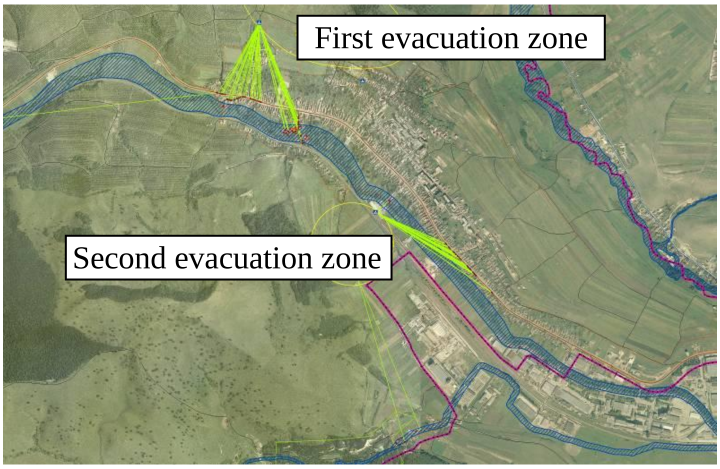
During the first 10 minutes, 12.5 % from the constructions can be evacuated, in the next 10 minutes 33 %, in 30 minutes 47.5%, in an hour nearly 69%, and in two hours, 82%. After four hours, there are only 45 constructions in the Mera locality which cannot be evacuated.



10 minutes



30 minutes

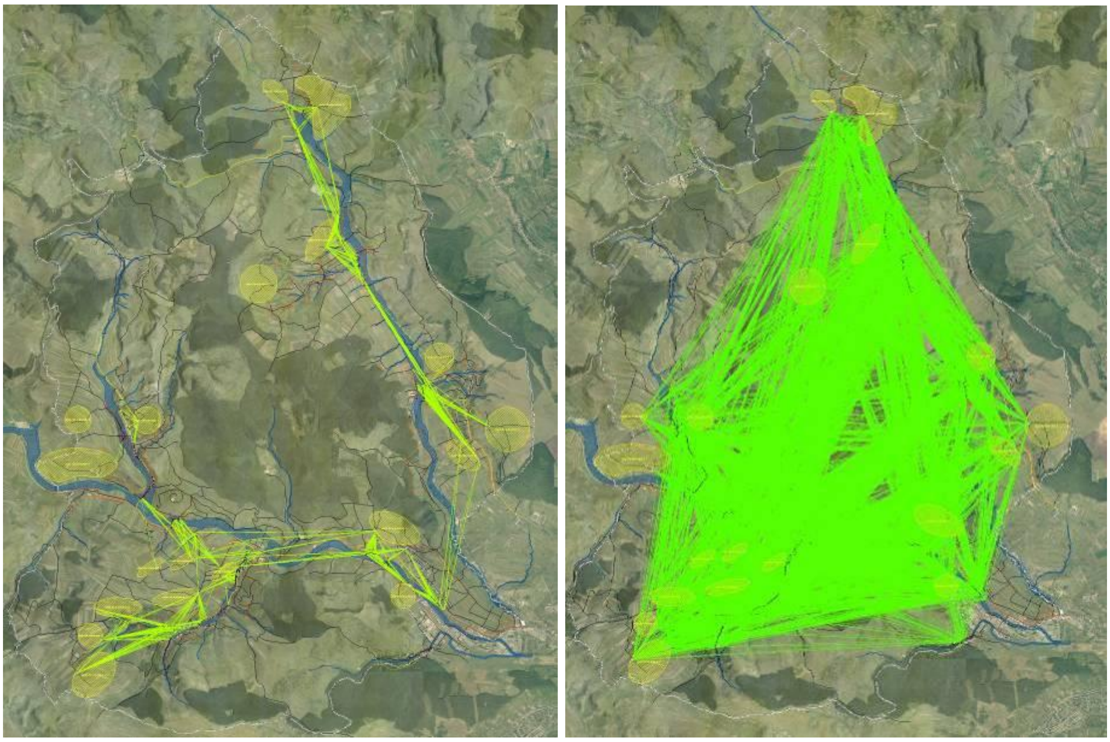


60 minutes

Figure 139. Assignation of houses and annexes in the Baciu locality, to a single evacuation zone.

In the fifth scenario we proposed to identify all zones where a building can be evacuated during 30, 60, 90, 120, 180 minutes. People living in a house can be transported to more than one evacuation zone, within the time imposed. For the scenario, the same type of analysis was applied: **Creating an OD Cost Matrix**. For example, the results obtained for evacuation times of 30 and 180 minutes are presented in Figure 141 for the entire Baciu commune.

During the evacuation time set to a 30 minutes were identified 846 routes. After 180 minutes, the residents of each household can choose from several evacuation zones the one in which each want to be transported.



In 30 minutes In 180 minutes

Figure 141. Assignation of floodable households to several evacuation zones, depending on the default access time.

In the sixth scenario, from organizational and sanitary considerations two evacuation zones were assessed for each locality: one for people and the other for animals and fowl. The person responsible for organizing the evacuation activity should know exactly the number of people, animals and fowl, the house numbers where each of them lives, the evacuation zone where they will be transported, the number and type of vehicles necessary, the lengths of the transport routes, the amount of fuel required for the vehicles etc. The type of analysis applied on data by this scenario allows the calculation of the time needed to cover the distance of each route identified by the system and consists in an attempt of temporal modeling of the dynamic evacuation process.

In the locality Baciu there are 35 homes and 12 annexes to be evacuated. In these constructions live 119 persons, 69 animals, and 150 fowl. In order to find the transport routes to the evacuation zones we chose the **New Route** spatial analysis type.

For each locality were created routes corresponding to the following cases:

Case 1: The vehicle travels the route passing through every stop but without halting. For Baciu, the transport duration was 42 minutes, starting at 8 a.m. This is the route that the vehicle has to pass through when returning to the mayor which is the starting point.

Case 2: At each stop, the vehicle halts for 30 minutes to allow people to take their luggage and to board to be transported in the evacuation area. For example, in Baciu the transport time for the first route is 5 hours and 12 minutes.

Case 3: The standing time for each halting at each home is 60 minutes to enable people to take with them various objects that could be saved from waters, which leads for example in Baciu locality to a route time duration of 9 hours and 42 minutes to the evacuation point.

In real life, the standing time at a location varies from case to case. For exemplification, the first evacuation route obtained for the locality Baciu is presented in Figure 143.

The digital evacuation of animals was realized similarly, by uploading in the layer with stops the points corresponding to the annexes where the animals are held and as destination, the access point in the second evacuation zone established for the locality Baciu. Considering the number of domestic animals, it was considered that two transports have to be executes with specialized transport vehicles (Figure 144).

In Baciu commune, fowl can be transported with a single vehicle to the access point in the second evacuation area. The proposed route is presented in Figure 145. The settings for analysis are similar to the ones above. Depending on the capacity of the means of transport at the command of the mayor, the number of fowl or animals per transport can be determined.

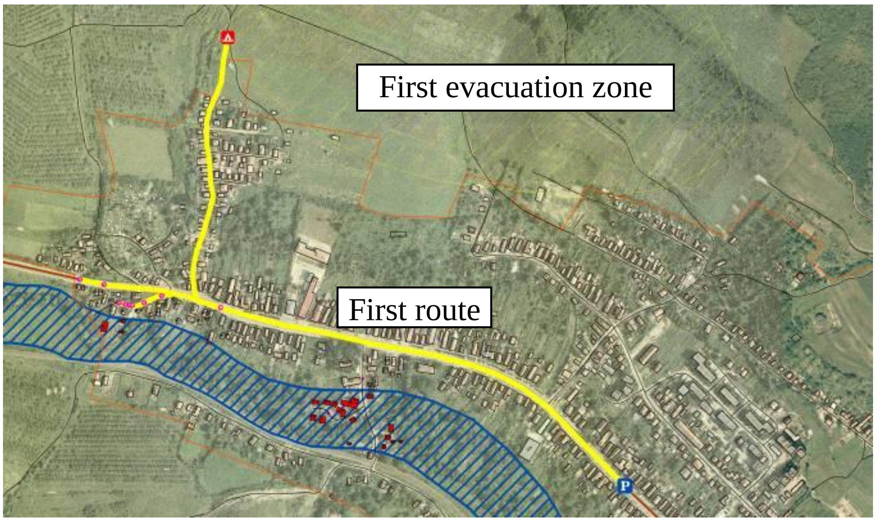


Figure 143. Evacuation routes for people in the Baciu locality

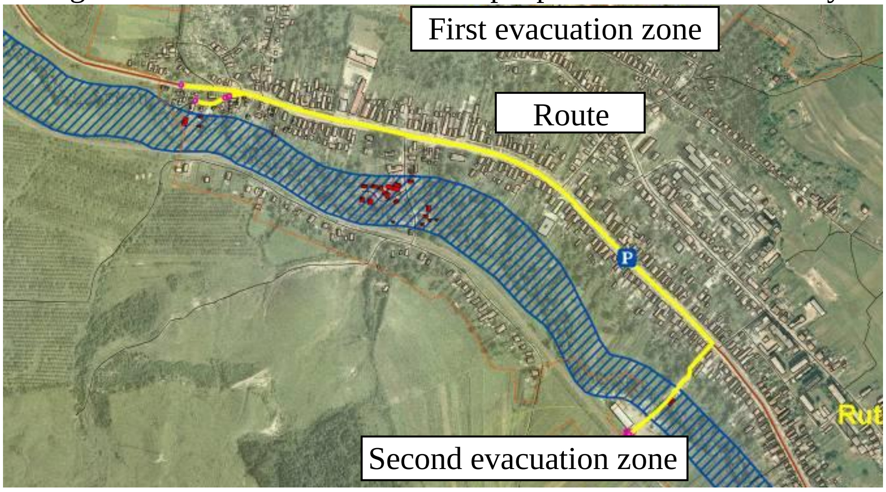


Figure 144. Evacuation routes for domestic animals in the Baciu locality.

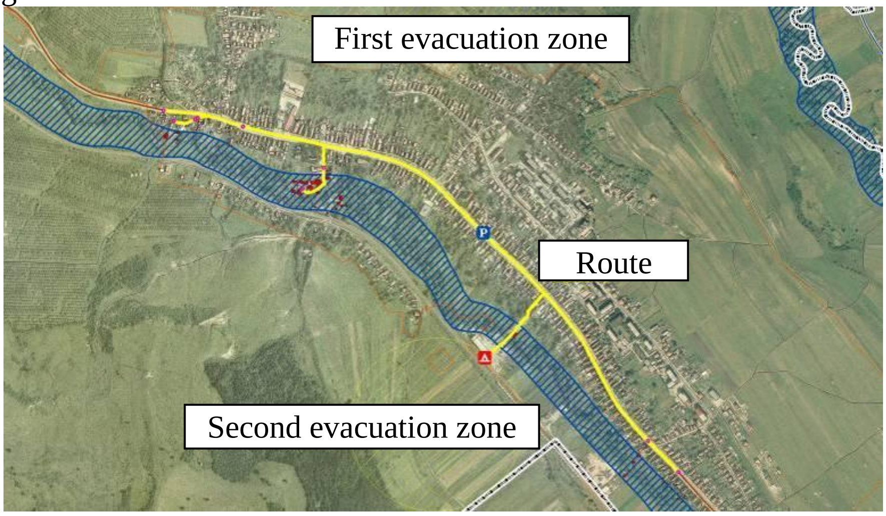


Figure 145. Evacuation route for fowl in the Baciu locality.

Similarly were realized analyses for the evacuation of people, animals and fowl for the other 6 localities. The obtained results evidence that the evacuation in the locality Baciu can be carried out in maximum 12 hours. The evacuation of the localities Coruşu, Rădaia, Săliştea Nouă, Suceagu, and Popeşti can be realized in acceptable times if there are no stops for more than 30 minutes at a location.

For the locality Mera, the halting times at each location should be as near to zero as possible, or the vehicles should start from within the area of this locality, in order that the evacuation be realized in 24 hours. The obtained results evidence the importance of the road pavement and of the depreciation state of the roads constituting the access route to the evacuation areas.

13. GENERAL CONCLUSIONS

For the management of emergency situations in Romania was realized the first geodatabase structure for flooding and leakage from the hillsides phenomena required to draw up the Defense plan against floods, hazardous meteorological phenomena, accidents in hydrotechnical constructions and accidental pollution which is worked out at the level of a commune.

In G.I.S. was created the first Network Dataset structure and used to study the people, animals and fowl evacuation in the management of emergency situations in the case of floods in Romania.

The history and versioning of the database and applications provides allocation of the fourth dimension to data with spatial reference, enabling to obtain the entity time evolution, which can represent an object materialized in a physical form, a process or an evolutionary phenomenon.

The manner in which the study was realized incites and proves to the experts from urban and spatial planning, management of emergency situation that the G.I.S. systems are the necessary instruments in their current activity and that they must not possess thorough knowledge in computer science for their use.

In order that the efforts of government, competent authorities, organizations in the field and of the community to be coordinated and to have as result a community prepared to cope with the phenomenon of flooding, the flood management should be approached in an integrated manner at national level.

By similarity and adjustment of parameters and commands, the realized modeling and the analyses carried out by the study, can be also applied and used in other fields such as: transport of passengers, cargo, and information through various media interconnected in networks, supply of units or warehouses, emergency medical assistance as well as for military purposes.

14. PERSPECTIVES OF THE RESEARCH

The present work demonstrated that the use of G.I.S. can improve decision-making process as well as strategic and tactical research, through the scenarios that can be developed, in order to draw up the best operational plans. The management approach with the new technologies imprints activity a new spatial-temporal perspective. The Romanian government should manifest more care and concern for the citizen, by adopting a legislative framework for the documentation elaboration with the purpose of sustainable space development and the management of a community, respectively for the measures to be taken.

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